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Indian Standard

SPECIFICATION FOR ELECTRIC CABLES FOR AIRCRAFT

PART 3 NYVIN TYPE ELECTRIC CABLES

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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SPECIFICATION FOR ELECTRIC CABLES FOR AIRCRAFT

PART 3 NYVIN TYPE ELECTRIC CABLES

Aircraft Electrical Equipment Sectional Committee, ETDC 55

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Indian Standard

SPECIFICATION FOR ELECTRIC CABLES FOR AIRCRAFT

PART 3 NYVIN TYPE ELECTRIC CABLES

0. FOREWORD

0.1 This Indian Standard (Part 3) was adopted by the Indian Standards Institution on 25 March 1987, after the draft finalized by the Aircraft Electrical Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The general requirements and tests for electric cables for aircraft are covered in Part 1 of this standard. This standard (Part 3) specifies the particular requirements and tests for Nyvin type of cables used for aircraft.

0.3 The aircraft industry is one of the potential users of cables and conductors In view of the severity that has to be encountered by the various accessories that go into the making of an aircraft, it is necessary that they should be subject to a strict quality audit.

0.4 With a view to specifying the various requirements that have to be satisfied by the cables to be used in aircraft and in order to standardize the type of cables to be used so that there could be substantial saving in material, this standard has been brought out.

0.5 In preparing this standard, considerable assistance has been derived from BS G 177 Nyvin type of electrical cables for aircraft, issued by the British Standards Institution.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part 3) specifies the requirements and tests for 'Nyvin' type cables for aircraft wiring suitable for use in circuits in which the voltage between conductors, between a conductor and a metal braid surrounding it and between a conductor and the aircraft structure does not exceed 600 Vrms and the frequency does not exceed 1600 Hz. These cables are suitable for use where, in continuous service, no combination of ambient temperature and conductor current produces a stabilized conductor temperature which exceeds 105°C. These cables are also suitable for fixed wiring in aircraft when temperatures up to —75°C are encountered, but are not suitable for severe flexing at temperatures below —30°C.

1.2 These cables do not support combustion.

1.3 The cables are suitable for use in areas where ester-base fluids are present.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following terms and definitions in additions to those given in Part 1, shall apply.

2.1 Nyvin — Cable with a copper conductor and an insulation of PVC compound and glass braid with an outer protective covering of nylon.

2.2 Nyvinal — Cable similar to the Nyvin range but with a conductor of aluminium instead of copper.

2.3 Nyvinmet — Cable similar to the Nyvin range but with the addition of a metal braid.

2.4 Nyvinmetsheath — Cable similar to the Nyvin range but with the addition of a metal braid and a sheath comprising a polyester film tape, a nylon fibre or ribbon braid, nylon lacquered, to prevent abrasion in installations where Nyvinmet cable is in contact with cables without a metal braid.

2.5 Dunyvin — Two-core cable consisting of two single Nyvin cables twisted together.

2.6 Trinyvin — Three-core cable consisting of three single Nyvin cables twisted together.

2.7 Dunyvinal — Two-core cable consisting of two single Nyvinal cables twisted together.

2.8 Trinyvinal — Three-core cable consisting of three single Nyvinal cables twisted together.

3. CLASSIFICATION

3.1 The cables shall be classified and identified by a series of numbers indicative of the conductor cross-sectional area as given in Appendix A. The maximum current ratings shall be as given in Appendix C.

4. MATERIALS

4.0 The material requirement shall comply with **3** of Part 1 of this standard. Should any deviation occur between the details of Part 1 and those of this standard, the provisions of the latter shall apply.

4.1 Copper Conductors and Wires — Copper conductors and wires shall be in accordance with IS : 8130-1984* as far as applicable. Wires taken from conductors, but not from braids, shall meet the requirements for maximum tensile strength and minimum elongation at break specified in **9.4.**

4.2 Aluminium Conductors and Wires — Aluminium wires shall be three-quarter hard and before stranding, shall comply with the requirements of IS : 8130-1984* as far as applicable. Aluminium wires taken from the standard or bunched conductor shall comply with the tensile and wrapping test requirements of **9.4.**

NOTE — Certain types of crimped termination may not be suitable for use with aluminium conductor.

4.3 PVC Insulation — The PVC insulation shall be a white, high temperature grade insulation of such quality that the finished cable complies with all the test requirements of this standard.

4.4 Glass Braid — The free alkali content of the glass shall not exceed one percent. The glass shall be of such quality that the finished cable complies with all the test requirements of this standard.

4.5 Nylon Braid and Lacquer — The nylon braid shall be in the form of twisted fibres or ribbon. The nylon braid and lacquer shall be free from ingredients likely to cause staining or discolouration of the cable, and the braid shall be of such quality that the finished cable complies with all the test requirements of this standard.

4.6 Nylon Sheath — The nylon sheath shall be stabilized, colourless and transparent, and free from ingredients likely to cause staining or discolouration of the cable. It shall be of such a quality that the finished cable complies with all the test requirements of this standard.

4.6.1 Specimens of the nylon sheath removed from the finished cable shall comply with **9.20.**

*Specification for conductors for insulated electric cables and flexible cords (*first revision*).

4.7 Polyester Film Tape – The tape shall be of such quality that the finished cable complies with all the test requirements of this standard.

5. CONSTRUCTION

5.0 General

5.0.1 *Conductor* — The conductor shall be bunched, stranded, or rope stranded as specified. It shall consist of tinned annealed copper wires complying with the requirements of **4.1** or of aluminium wires complying with the requirements of **4.2**. Joints in single copper wires shall be brazed or hard soldered but there shall be not more than one such joint in each 50 metres of wire, and the complete conductor shall not be joined. In aluminium conductors, the ends of the wires may be tucked into the conductor.

5.0.1.1 The number and diameter of individual wires and the formation to be used for the complete conductor shall be as specified in Tables 1 and 2.

5.0.2 *Insulation* — The insulation adjacent to the conductor shall consist of a white PVC compound as specified in **4.3**. The insulation shall be uniform circular cross-section throughout the length of the cable and the conductor shall be evenly centred in the insulation.

5.0.2.1 The insulation shall not be loose, but it shall be possible to strip the complete insulation, leaving the conductor in a condition sufficiently clean to permit satisfactory connection to terminations.

5.0.2.2 The radial thickness at any point in the wall of the PVC compound shall be not less than the values given in Tables 1 and 2.

5.0.2.3 A glass fibre braid and uncoloured, unless otherwise specified in this standard, shall be applied over the PVC insulation. The braid shall be closely woven and of uniform surface. The number of spindles and ends per spindle shall be such as to ensure that the filling factor is not less than 0·70. The lay factor for the different sizes of cable shall not be less than the following:

Cable Size	*Lay Factor*
22	1·5
20	1·5
18	1·5
16	2·0
14	2·25
12 and larger	3·0

The formulae to be used for calculating the above details are given in Appendix B.

TABLE 1 DETAILS OF UNINYVIN CABLES

(*Clauses* 5.0.1.1, 5.0.2.2 *and* 9.18)

Cable Name	Nominal Conductor Area	Conductor		Diameter of Conductor		Minimum Radial Thickness of PVC	Thickness of Nylon Sheath		Thickness of Nylon Braid and Lacquer		Overall Diametre of Finished Cable		Maximum Conductor Resistance for 1 000 m at 20°C	Nominal Weight kg/100 m (for Ref Only)
		No. of Wires	Nomina Diameter	Maximum	Minimum		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	ohms	
	mm^2		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
22	0·347	19	0·152	0·838	0·737	0·229	0·173	0·076	0·178	0·076	2·0	1·8	54·312	0·650
20	0·556	19	0·193	1·041	0·940	0·229	0·178	0·076	0·178	0·076	2·3	2·0	33·85	0·932
18	0·966	33	0·193	1·321	1·219	0·229	0·178	0·076	0·178	0·076	2·5	2·3	19·49	1·381
16	1·171	40	0·193	1·549	1·397	0·229	0·178	0·076	0·178	0·076	2·8	2·5	16·08	1·682
14	2·05	70	0·193	1·956	1·803	0·279	0·178	0·076	0·178	0·076	3·4	3·0	9·20	2·634
12	3·22	110	0·191	2·438	2·286	0·279	0·178	0·076	0·178	0·076	3·8	3·5	5·85	3·899
10	5·33	73	0·305	3·150	2·896	0·381	—	—	0·381	0·127	5·0	4·6	3·532	6·444
8	8·76	120	0·305	1·242	3·937	0·381	—	—	0·381	0·127	6·3	5·9	2·154	9·926
6	13·3	182 (7 × 26)	0·305	5·537	5·080	0·381	—	—	0·381	0·127	7·6	7·3	1·422	15·924
4	21·5	294 (7 × 42)	0·305	6·909	6·452	0·483	—	—	0·381	0·127	9·3	8·8	0·877	25·150
2	33·3	203 (7 × 29)	0·457	8·763	8·128	0·483	—	—	0·381	0·127	11·0	10·5	0·565	35·716
1	40·7	248 (1×14+18×13)	0·457	9·754	9.119	0·559	—	—	0·381	0·127	12·2	11·7	0·463	43·901
0	53·00	323 (19 × 17)	0·457	10·973	10·338	0·635	—	—	0·381	0·127	13·7	13·0	0·355	55·956
00	68·3	416 (2×21+17×22)	0·457	12·446	11·684	0·686	—	—	0·381	0·127	15·4	14·6	0·276	72·772
000	84·2	513 (19 × 27)	0·457	13·919	13·157	0·762	—	—	0·381	0·127	16·9	16·1	0·223	89·142
0000	109·0	666 (87 × 18)	0·457	15·621	14·859	0·787	—	—	0·381	0·127	18·7	17·9	0·173	112·804

TABLE 2 DETAILS OF UNINYVINAL CABLES

(*Clauses* 5.0.1.1, 5.0.2.2 *and* 9.18)

Cable Name	Nominal Conductor Area mm^2	Conductor		Diameter of Conductor		Minimum Radial Thickness of PVC mm	Thickness of Nylon Braid and Lacquer		Overall Diameter of Finished Cable		Maximum Conductor Resistance for 1 000 m at 20°C ohms	Nominal Weight (for Reference Only) kg/100 m
		Number of Wires	Nominal Diameter of Wires mm	Maximum mm	Minimum mm		Maximum mm	Minimum mm	Maximum mm	Minimum mm		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
8	8·31	41	0·508	4·064	3·810	0·508	0·381	0·127	6·4	5·8	3·587	4·673
6	14·2	70 (7 × 10)	0·508	5·359	5·055	0·508	0·381	0·127	7·7	7·2	2·100	9·450
4	21·3	105 (7 × 15)	0·508	6·655	6·274	0·584	0·381	0·127	9·1	8·6	1·400	11·608
2	34·1	168 (7 × 24)	0·508	8·382	7·874	0·584	0·381	0·127	10·9	10·4	0·879	19·049
0	53·9	266 (19 × 14)	0·508	10·617	10·109	0·711	0·381	0·127	13·7	12·6	0·554	23·811
00	69·3	342 (19 × 18)	0·508	12·141	11·506	0·711	0·381	0·127	15·2	14·5	0·436	30·061
000	84·7	418 (19 × 22)	0·508	13·539	12·954	0·838	0·381	0·127	17·0	16·3	0·358	36·907
0000	107·0	532 (19 × 28)	0·508	14·910	14·275	0·838	0·381	0·127	18·4	17·7	0·279	45·836

5.0.2.4 Cables Uninyvin 22 to Uninyvin 12 shall have an outer protective covering of a concentric nylon sheath. Tables Uninyvin 10 to Uninyvin 0000 and all Uninyvinal cables shall have an outer protective covering of a nylon braid coated with clear nylon lacquer. Alternatively, all sizes may have an outer covering of braided nylon ribbon coated with a clear nylon lacquer.

5.1 Uninyvin Cables — The cables shall consist of single cores complying with the requirements of **4.1**, **4.3**, **4.4**, **4.5** or **4.6** and **5.0**.

5.1.1 When required by the purchaser, phase identification shall be provided on the cables by tracers, in the colours — red, yellow or blue, with a left-hand lay, from two adjacent spindles in theo uter braid. Such cables shall be identified for ordering purposes by the addition to the cable nomenclature of the word 'red', 'yellow' or 'blue' as appropriate.

5.2 Uninyvinal Cables — The cables shall consist of single cores complying with the requirements of **4.2**, **4.3**, **4.4**, **4.5** and **5.0**.

5.2.1 When required by the purchaser, phase identification in accordance with **5.1.1** shall be provided on the cables.

5.3 Uninyvinmet Cables — The cables shall consist of nyvin cables to which has been added an overall metal braid. Tinned copper wires, as specified in **4.1** shall be used to form the metal braid. The braid shall be close fitting, but wherever the cable is cut it shall be possible to slide the metal braid back by hand a distance of 100 mm in a length of 600 mm, one end of the cable being clamped. The braid shall subsequently be capable of being returned to within 25 mm of its original position

5.3.1 Where breaks in the individual wires occur, the ends shall be soldered or tucked out of the braid and there shall not be more than one such break in any 25 mm length of cable, or in each 10 metres of individual wire.

5.3.2 Where renewal of the spindles is necessary, the ends shall be tucked out of the braid, and there shall not be more than one spindle renewal in any 300 mm length of cable.

5.3.3 There shall be no joints in the complete braid.

5.3.4 The diameter of wire used shall be as stated in Table 3. The number of spindles and ends per spindle shall be such as to ensure that the filling factor is not less than 0·70. The lay factor shall not exceed 3. The formulae to be used for the calculation of the above details are given in Appendix B.

TABLE 3 DETAILS OF NYVINMET AND NYVINMETSHEATH CABLES

(*Clauses* 5.3.4 *and* 5.4.1)

Cable Name		Overall Diameter		Diameter of Braiding Wire	Nominal Weight (for Reference only)
Uni-nyvinmet	Uninyvin-metsheath	Maximum	Minimum		
		mm	mm	mm	kg/100 m
(1)	(2)	(3)	(4)	(5)	(6)
—	22	3·2	2·7	0·102	1·652
—	20	3·4	2·9	0·102	2·113
—	18	3·7	3·2	0·102	2·738
—	16	3·9	3·3	0·102	3·110
14	—	4·4	3·8	0·193	5·253
12	—	4·8	4·2	0·193	6·995
10	—	6·0	5·4	0·193	9·658
8	—	7·3	6·7	0·193	13·900

5.4 Uninyvinmetsheath Cables — The cables shall consist of Uninyvin cables, with or without the cable size identification, to which has been added a metal braid in accordance with the requirements of **5.3**. The cables shall be sheathed overall by the application successively of polyester film taps, nylon fibre or ribbon braid, and a coating of clear nylon lacquer. The sheath shall not be loose but it shall be possible to remove it without damaging the metal braid.

5.4.1 The overall dimensions of the cable shall comply with the values specified in Table 3.

5.5 Dunyvin, Trinyvin, Dunyvinal and Trinyvinal Cables — The cables shall consist of two or three Uninyvin or Uninyvinal cables of the same size, with phase identification in accordance with **5.1.1** in the combinations stipulated by the purchaser. The cables shall be assembled from Uninyvin or Uninyvinal cables for which the manufacturer has type approval, the cores being twisted together with a right-hand lay approximately 12·5 times the pitch circle diameter for sizes 22 to 4 and of approximately 16 times the pitch circle diameter for sizes 2 to 0000.

5.6 Fastness of Colours of Cables — All colours shall be fast to light and moisture. The materials used shall be capable of retaining their colours after storage for long periods in the tropics.

6. IDENTIFICATION OF CABLE SIZE

6.1 Cables shall be identified by the nomenclature, for example, 'Nyvinal 0000', permanently and legibly printed.

Preferably, the horizontal axis of the characters should be parallel to the axis of the cable. The printing, which shall be in red on Nyvin cables and in black on Nyvinal cables, shall be separated by spaces of 150 to 300 mm. The minimum height of the characters shall be approximately two-thirds the maximum overall diameter of the cable for sizes up to and including size 10 and the same height of character used for cables of that size may be used for all cables above that size. A longitudinal line in the spaces is not permissible.

7. IDENTIFICATION OF MANUFACTURER AND YEAR OF MANUFACTURE

7.1 The manufacturer shall not mark the cable itself with his name and address, but with a code letter in accordance with the Bureau of Indian Standards list of manufacturers' identification marks for aircraft electric cables. The cable shall also be marked with a letter to indicate the year of manufacture. All manufacturers shall use the same letter for the current year, which shall be as stated in Table 2 of Part 1 of this standard. The letter to be used shall be that for the year in which the PVC is extruded.

7.1.1 The identification letters shall be of the size and colour specified in **6**, and shall be printed on the cable immediately following the cable size identification as specified in **6.1**. The manufacturer's code letter shall precede the letter indicating the year of manufacture.

8. PACKING AND MARKING

8.1 Packing — The length of cable, in one piece and on a separate coil, reel or drum shall be 100 m or as stated on the contract.

8.1.1 After testing, the cable shall have the ends sealed to prevent the ingress of moisture.

8.2 Marking — Each length shall bear a linen label giving the following particulars:

a) Name of manufacturer;
b) Name of cable, for example, Uninyvin 22;
c) Size of conductor, for example, 19/0·152;
d) The number of this standard, Ref IS : 10241 (Part 2);
e) Date of manufacture (month and year);
f) Release reference number; and
g) Actual length in metres.

8.2.1 Each coil, reel or drum may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions, under which a licence for the use of the Standard Mark may be granted to manufacturers or producers, may be btained from the Bureau of Indian Standards.

9. TESTS

9.0 General

9.0.1 The provisions of **7.1** of Part 1 of this standard shall apply.

9.1 Classification of Tests

9.1.1 *Type Tests* — The following shall constitute type tests:

a) Construction (*see* **9.2**),
b) Identification, packing and marking (*see* **9.3**),
c) Mechanical strength of wires from conductors (*see* **9.4**),
d) Non-inflammability test (*see* **9.5**);
e) Tinning test (*see* **9.6**),
f) Resistance to fluids (*see* **9.7**),
g) Heat test (*see* **9.8**),
h) Ageing in air (*see* **9.9**),
j) Low temperature test (*see* **9.10**),
k) Flexibility (*see* **9.11**),
m) Voltage test (*see* **9.12**),
n) Voltage test on core (*see* **9.13**),
p) Insulation resistance test on core (*see* **9.14**),
q) Spark test on core (*see* **9.15**),
r) Voltage test on complete cable (*see* **9.16**),
s) Surface creepage test (*see* **17**),
t) Conductor resistance test (*see* **9.18**),
u) Properties of PVC insulation (*see* **9.19**),
v) Melting point of nylon (*see* **9.20**),
w) Test for pliability (*see* **9.21**), and
y) Climatic test (*see* **9.22**).

9.1.1.1 For the tests in **9.5, 9.7, 9.8, 9.9, 9.10, 9.11, 9.17, 9.19** and **9.21,** the metal braid on Uninyvinmet cables shall be removed.

For the tests in **9.9.2, 9.17, 9.19,** and **9.21** the metal braid and the sheath on Uninyvinmetsheath cables shall be removed.

9.1.1.2 Type tests shall each be made on separate specimens from a sample selected from each of the following groups of cables, a sample being regarded as representative of all the sizes of cable in its group provided that they are made by the same process and with the same materials within the group from which it is selected:

Nyvin cables

Group 1 — Uninyvin 22 to 16
Group 2 — Uninyvin 14 and 12
Group 3 — Uninyvin 10 to 2
Group 4 — Uninyvin 1 to 0000

In Group 1, the cable to be tested shall be the smallest size, it is proposed to manufacture.

Nyvinal cables

Group 1 — Uninyvinal 8 to 2
Group 2 — Uninyvinal 0 to 0000

Nyvinmet cables

Group 1 — Uninyvinmet 14 to 8

In this group the cable to be tested shall be the smallest size, it is proposed to manufacture.

Nyvinmetsheath cables

Group 1 — Uninyvinmetsheath 22 to 16

9.1.2 *Acceptance Tests* — The following shall constitute acceptance tests:

a) Construction (*see* **9.2**),
b) Identification, packing and marking (*see* **9.3**),
c) Mechanical strength of wires from conductors (*see* **9.4**),
d) Non-inflammability test (*see* **9.5**),
e) Tinning test (*see* **9.6**),
f) Voltage test on core (*see* **9.13**),

g) Insulation resistance test on core (*see* **9.14**),
h) Spark test on core (*see* **9.15**),
j) Voltage test on completed cable (*see* **9.16**),
k) Conductor resistance test (*see* **9.18**), and
m) Properties of PVC insulation (*see* **9.19**).

9.1.2.1 The acceptance tests shall be made on each batch of 100 000 metres of cable or at least once during each two months' production, whichever is less. A batch of cable may consist of different sizes and types but, wherever possible, the sample should be representative of the sizes and types being produced.

9.1.2.2 Two samples of cable shall be selected from the production batch, one sample being of the smallest sizes produced. Specimens from each of these samples shall each be subjected to the tests in **9.1.2**. Should either of the samples fail in any one of the tests, the test shall be repeated on specimens from four further samples taken at random. Should any one of these samples fail, the batch shall be deemed not to comply with this specification.

9.1.3 *Routine Tests* — The following shall constitute routine tests:

a) Construction (*see* **9.2**),
b) Identification, packing and marking (*see* **9.3**),
c) Voltage test on core (*see* **9.13**),
d) Insulation resistance test on core (*see* **9.14**),
e) Spark test on core (*see* **9.15**),
f) Voltage test on complete cable (*see* **9.16**),
g) Conductor resistance test (*see* **9.18**), and
h) Properties of PVC insulation (*see* **9.19**).

9.1.3.1 The routine tests shall be carried out on every length of cable.

9.2 Construction — All cables shall be checked to ensure compliance with the requirements of this standard relating to construction and dimensions. All completed cables shall be examined along the entire length for defective workmanship.

9.3 Identification, Packing and Marking — Each coil, reel or drum of complete cable shall satisfy the requirements of **7.**

9.4 Mechanical Strength of Wires from Conductors

9.4.1 The tensile strength of each copper or aluminium wire taken from the finished cable, and the minimum elongation of each copper wire taken from the finished cable conform to the values given in Table 11. For these tests the gauge length on the test specimens shall be 250 mm and the clamps shall be separated at a rate not exceeding 102 mm per minute. The tensile strength shall be calculated on the original cross-sectional area of the wire.

9.4.2 Aluminium wires shall not break when subjected to the following test:

Wrap the wire round a wire of its own diameter to form a close helix of eight turns. Unwrap six turns and again closely re-wrap them in the same direction as the first wrapping.

9.5 Non-inflammability Test — The number of specimens to be tested shall be as specified in Table 10. All specimens shall be cut consecutively from the same coil. They shall be freely exposed in an atmosphere of 75 percent relative humidity at a temperature of 20 $\pm$ 5°C for a period of 16 hours before testing.

Each specimen shall be supported at an angle of 45° in a draught free chamber and the hottest point of a vertical 76 mm non-luminous flame 9·5 mm Bunsen burner with a blue cone 25·4 mm high shall be arranged to impinge on the central portion of the specimen for the time specified in Table 10. During the test no flaming particles shall fall from the samples After the source of the flame has been removed, the cable shall meet the following requirements:

a) The cable shall cease to burn within five seconds.

b) The total length burned or charred shall not exceed 76 mm.

9.6 Tinning Test — The tinning of copper conductors shall be tested for compliance with the requirements of IS : 8130-1984* as far as applicable.

9.7 Resistance to Fluids — Five test specimens shall be bent into single loops, each with an internal diameter fourteen times the maximum specified diameter of the complete cable. The specimens shall be immersed each in one of the fluids listed in Table 4 with the cable ends out of the liquid, and maintained at the stated temperature for not less than twenty-four hours.

*Specification for conductors for insulated electric cables and flexible cords (*first revision*).

TABLE 4 RESISTANCE TO FLUIDS

(*Clause* 9.7)

Fluid Represented	Test Fluid	Temperature of Test °C	Maximum Change in Diameter (Percent)
(1)	(2)	(3)	(4)
Aviation turbine fuel	Kerosine		
Fuel	70 percent *iso*-octane and 30 percent toluene by volume	20 ± 5	5
Hydraulic fluid	80 percent ethylene glycol monoethyl ether + 20 percent castor oil by volume Ester base hydraulic fluid	50 ± 2	5
Ester-based lubricating oil		100 ± 2	5

At the conclusion of this period each cable shall be removed from the fluid, straightened, wiped and cooled to room temperature. Within one hour after straightening, the cable shall be bent 260° around a mandrel of the same diameter as the original loop, in the same direction as the initial bend. The specimen shall be kept on the mandrel for one minute and then unwound. The cable shall show no signs to normal vision, of splitting, cracking, or other deterioration, and the change in diameter shall not exceed the values given in Table 4. At the end of the test, the identification of the cable shall remain effective.

9.8 Heat Test — For the purposes of this test, six sample cables each approximately 150 mm long shall be laid about a central cable and laced together and stored at a temperature of 115°C for a period of one hour. At the end of that period and after being allowed to cool to a temperature of 20°C, the cables shall be unlaced and shall separate without sticking.

9.9 Ageing in Air — A suitable length of cable, having the insulation removed for 25 mm at each end, shall be bent at least half-way round a cylindrical mandrel of diameter as specified in Table 5. The conductor shall be loaded in such a manner that the portion of the compound between the conductor and the mandrel is under compression while the conductor has attached at each end the load specified in Table 5. These

conditions shall be maintained for a period of 120 hours in an air oven at a constant temperature of 120 ± 2°C. On removal from the air oven, the specimen shall be cooled to between 20°C and 25°C within a period of one hour. When cooled, the cable shall be freed from the load, removed from the mandrel and straightened. The specimen shall then be subjected to the tests in **9.9.1** and **9.9.2** successively, and subsequently the insulation shall be removed from the specimen and the conductor examined for pitting.

TABLE 5 DIAMETERS OF MANDRELS AND TEST LOADS FOR BEND TESTS

(*Clauses* 9.9, 9.9.1 *and* 9.9.2)

Cable		Maximum Diameter of Mandrel	Test Load
Uninyvin	Uninyvinal	mm	kg
(1)	(2)	(3)	(4)
22	—	114	0·3
20	—	114	0·3
18	—	114	0·4
16	—	165	0·4
14	—	165	0·4
12	—	165	1·4
10	—	254	1·4
8	8	254	1·4
6	6	254	2·7
4	4	254	2·7
2	2	254	2·7
1	—	254	2·7
0	0	254	4·5
00	00	254	4·5
000	000	254	4·5
0000	0000	254	4·5

9.9.1 *Bend Test* — In a temperature maintained between 20°C and 25°C, the specimen shall be secured to the mandrel and the other end to the load weight specified in Table 5. The mandrel shall be rotated until the full length of the specimen is wrapped round the mandrel and is under the specified tension with adjoining turns in contact. The mandrel shall then be rotated in the reverse direction until the full length of the cable which was outside during the first wrapping is now next to the mandrel. This procedure shall be repeated until two bends in each direction have been formed in the same section of the cable. There shall be no cracking or puncturing of the finished cable as a result of this test.

9.9.2 *Dielectric Test* — The uninsulated ends of the specimen shall be fastened in metallic contact to a metal bar. Care shall be taken to avoid fraying the ends of the insulation. The distance between the two uninsulated ends of the cable shall be equal to the diameter of the mandrel specified in Table 5. The specimen shall be immersed in a 5 percent aqueous sodium chloride solution at a temperature of 20 to 25°C so that the insulation protrudes 38 mm from the surface of the liquid. After submersion for five hours, a potential with a waveform as specified in **9.13**, and a frequency at any value from 25 to 100 Hz inclusive, shall be applied between the conductor and an electrode in contact with the liquid.

This voltage shall be increased at a uniform rate from 0 to 1 500 volts within half a minute and maintained at 1 500 volts for a period of five minutes without breakdown. There shall be no cracking or puncture of the cable at the end of this test.

9.10 Low Temperature Test — The cable shall be conditioned for a period of not less than 16 hours in an atmosphere with a temperature of 20 ± 5°C and a relative humidity of 75 percent. The mandrels used in the test shall be of metal and shall be allowed to cool to the specified temperature with the cable. A specimen of the cable, at least 300 mm long, shall be stored in air at a temperature of -30 ± 2°C for a period of six hours, immediately after which it shall be wound on a mandrel, the diameter of which is ten times the maximum specified diameter of the cable. The rate of winding shall be approximately one revolution per second. After one minute and while still on the mandrel, the component parts of the cable shall not show to normal vision any signs of cracking.

NOTE — This test is not applicable to cables of size 4 and larger.

9.11 Flexibility — The cable shall be conditioned for a period of not less than 16 hours in an atmosphere with a temperature of 20 ± 5°C and a relative humidity of 75 percent. A specimen of the complete cable shall be wound on a mandrel at a temperature of 20 ± 2°C, under a tensile load, into a close helix of at least three turns. The mandrel diameter and the load applied to the cable shall be in accordance with Table 6. The complete test shall comprise five test cycles, each cycle consisting of the winding of the cable on the mandrel, unwinding and re-winding in the reverse direction so that the surface of the cable inside the helix during the first winding is on the outside of the helix upon re-winding. No part of the cable shall show signs of damage after this test. Slight puckering of the nylon sheath shall not be considered a damage.

9.12 Voltage Test — At the conclusion of each of the tests specified in **9.7**, **9.10** and **9.11**, each specimen shall be immersed in water and, whilst so immersed, shall withstand a test voltage of 1500 Vrms for one minute applied between the conductor and the water.

TABLE 6 DIAMETERS OF MANDRELS AND TEST LOADS FOR FLEXIBILITY TEST

(*Clause* 9.11)

CABLE	DIAMETER OF MANDREL	TEST LOAD kg
(1)	(2)	(3)
Uninyvin 22 to 4 Uninyvinmetsheath	3 × maximum specified diameter of cable	2·3
22 to 16		
2 and 1		4·5
0 to 0000	6 × maximum specified diameter of cable	9·0

TABLE 7 PLIABILITY

(*Clause* 9.21)

CABLE	ROTATION OF COUNTERBALANCE GIVEN WEIGHTS			
	Weight	Rotation	Weight	Rotation
(1)	(2)	(3)	(4)	(5)
	g	degrees	g	degrees
Nyvin 22	20	35	30	55
Nyvin 20	20	25	30	45

9.13 Voltage Test on Core — Except when tested in accordance with **9.15**, all cores shall be immersed in water at room temperature for not less than twelve consecutive hours; at the end of that time and, whilst so immersed, it shall withstand the voltage shown in Table 8 applied gradually and maintained continuously for fifteen minutes. The regulation of the supply for the voltage test shall be such as to maintain the specified voltage on the cable throughout the test. The peak value of the voltage wave shall be within five percent of $\sqrt{2}$ × rms value and the frequency shall be at any value from 25 to 100 Hz.

TABLE 8 ELECTRICAL TESTS ON CORES AND CABLES

(*Clauses* 9.13, 9.14 *and* 9.15)

Voltage Test	Insulation Resistance		Equivalent Spark Test kV (rms)	
	Test Voltage	Minimum Resistance for	Core	Cable
(Vrms)	(dc)	1 000 m		
(1)	(2)	(3)	(4)	(5)
1 500	500	16·404	3 kV up to and including Uninyvin 8 and Uninyvinal 8	6
			4 kV above Uninyvin 8 and Uninyvinal 8	8

9.14 Insulation Resistance Test on Core — After the application of the voltage test specified in **9.13** and whilst the core is still immersed, the insulation resistance for 1 000 m measured between the conductor and the water after one minute's electrification with the voltage shown in Table 8, shall be not less, when corrected to a temperature of 20°C, than the value stated in Table 8. The rate of change of apparent insulation resistance during the one minute's electrification shall be steady.

9.15 Spark Test on Core — A spark test in accordance with IS : 694-1977* all dry cores and a voltage and insulation resistance test on 5 percent of all the cores may be made instead of the voltage and insulation resistance tests specified in **9.13** and **9.14**. The spark test voltage shall be in accordance with Table 8 and the voltage and insulation resistance tests in accordance with **9.13** and **9.14**.

9.16 Voltage Test on Completed Cable — A spark test in accordance with Table 9 shall be made on all completed cables except metal-braided cables. Completed metal braided cables shall, in the dry state, withstand the voltage given in Table 9 applied for one minute between the conductor and the metal braiding.

In addition, for Uninyvinmetsheath cables, a test at the voltage given in Table 9 shall be applied between the metal braid and a suitable electrode system on the outside of the cable. The cable shall withstand the voltage for one minute.

9.17 Surface Creepage Test — A 760 mm length of cable shall be used with the insulation removed 25·0 mm at each end, care being taken not to fray the end of the insulation. The cable shall then be immersed in a

*Specification for PVC insulated cables for working voltages up to and including 1 100 volts (*second revision*).

5 percent aqueous sodium chloride solution at a temperature of 50 ± 2°C for twentyfour hours with the ends of the insulation protruding 38 mm above the surface of the solution end with a current limiting resistance of 75 000 ohms inserted in the circuit. At the end of that period, while the cable is still immersed and at room temperature, a voltage of 1 400 volts dc shall be applied between the conductor and the solution for one minute and the leakage current flowing shall not exceed 0·2 milliampere.

TABLE 9 VOLTAGE TEST ON COMPLETED METAL-BRAIDED CABLES

(*Clause* 9.16)

TEST	VOLTAGE
(1)	(2)
Between core and metal braid	1 500 Vrms
Between metal braid and outside of cable	100 to 250 dc or ac peak

TABLE 10 NON-INFLAMMABILITY TEST

(*Clause* 9.5)

CABLE	TIME OF FLAME APPLICATION	SPECIMENS TESTED
(1)	(2)	(3)
Uninyvin 22 to 16 and Uninyvinmetsheath 22 to 16	5 seconds	10
Uninyvin 14 to 0000 inclusive, all Nyvinal and Uninyvinmet 14 to 8	15 seconds	1

TABLE 11 TENSILE TESTS ON WIRES FROM CONDUCTORS

(*Clause* 9.4)

MATERIAL	DIAMETER mm	TENSILE STRENGTH N/mm	MINIMUM ELONGATION (PERCENT)
(1)	(2)	(3)	(4)
Copper	0·51 to 0·30	Not greater than 302·0	13·5
	0·29 to 0·08	Not greater than 309·0	9·0
Aluminium	0·51	Not less than 127·0 and not greater than 169·0	—

9.18 Conductor Resistance Test — The conductor resistance shall be measured on all completed cables and the resistance of a single conductor per 1 000 metres of the finished cable shall not exceed the values stated in Tables 1 and 2 (for copper and aluminium respectively) when corrected to the specified temperature.

9.19 Properties of PVC Insulation

9.19.1 As a type test, the following terts shall be done:

a) Eight samples of PVC insulation taken from the finished cable and prepared as described in IS : 5831-1984* shall be placed in an oven at 113 ± 2°C and maintained at that temperature for a period of 60 days.

The changes of air in the oven shall be between three and ten per hour. At the conclusion of this period, the test pieces shall be stored at 23 ± 1°C for at least 16 hours immediately before being tested for elongation at break. The test shall be made at 23 ± 2°C and the machine shall have grips of the self-tightening type. For a test piece consisting of a portion of the complete insulation the rate of traverse of the loading grip shall be such that the portion between the gauge marks on the sample is stretched at a rate not exceeding 600 percent per minute. For a dumb-bell, the rate of traverse of the loading grip shall not exceed 508 mm per minute.

Eight tests for elongation at break shall also be made under the same conditions on unaged samples taken from an adjacent length of cable.

The highest and the lowest values of test results shall be discarded and the average of the remaining six values determined for both the aged and the unaged samples.

The insulation after ageing shall retain at least 70 percent of its original elongation.

b) The softness number of the PVC insulation shall be not less than 10.

c) The PVC insulation shall be tested for compliance with the requirements of IS : 5831-1984* in respect of volume, resistivity except that the minimum volume resistivity shall be 5×10^{13} ohm at 20°C.

*Specification for PVC insulation and sheath of electric cables (*first revision*).

9.19.2 As a routine and acceptance test, the following tests shall be done:

a) The PVC insulation shall be tested in the manner described in **9.19.1**(a), except that the temperature shall be 135 ± 2°C, the period shall be four days, and the retention of elongation at least 90 percent of the original.

b) The PVC insulation shall be tested for compliance with the requirements of IS : 5831-1984* in respect of the tensile strength, elongation and heat test of hard grade insulation except that eight samples shall be used, the highest and lowest tensile strength values and the highest and lowest elongation values being discarded, and the average taken of the remainder, and the minimum tensile strength shall be 14 N/mm^2 and the elongation not less than 100 percent.

9.20 Melting Point of Nylon — The melting point of the sample of nylon sheath material shall be determined by either of the following methods. The temperature at which the edges of the samples commence to collapse shall be recorded as the melting point.

9.20.1 If the determination is made by means of apparatus of the Fisher-Johns type, that is, with an aluminium plate heated by an electric current passing through a controlled resistance, the sample is placed between two 18-mm cover glasses fitting into a well in the heated plate. A magnifier above the sample makes it possible to view it, and determine when melting actually takes place. The temperature is indicated by a thermometer which has the bulb immediately below the plate. For the purpose of testing by this method specimens shall be prepared by removing a sample from the completed cable and cutting a small rectangular section having sides approximately 3·0 × 1·0 mm. Specimens having clean cut edges and square corners are preferred. With the specimen inserted between the cover glasses, the temperature of the heated plate shall be raised rapidly to about 140°C, whereupon the heating shall be controlled so that it rises at a rate of approximately 4°C/min.

9.20.2 If the determination is made by means of an electrically-heated capillary melting apparatus, a small sliver of the nylon covering shall be inserted in the capillary tube which is then placed in the electrically-heated block in close proximity to the thermometer bulb. The sample shall be viewed through a magnifying lens against an illuminated background. The temperature shall be raised rapidly to about 140°C, whereupon the heating shall be controlled so that it rises at a rate of approximately 4°C/min.

The melting point of the sample shall not exceed 200°C.

*Specification for PVC insulation and sheath of electric cables (*first revision*).

9.21 Test for Pliability — Three samples of cable, each approximately 203 mm long, shall be cut consecutively from the same coil. The samples shall be laid on a flat surface so that the natural set of the cable can be seen and an ink line drawn along the cable on the outer periphery. The samples shall be suspended vertically in an oven at 100°C for 24 hours each sample having a 0 45 kg weight attached to the free end. Immediately after removal from the oven, the samples shall be stored at 75 percent relative humidity at 20 ± 5°C for a period of 24 hours. 12·7 mm from one end of the cable, two copper wires, approximately 0·6 mm diameter shall be looped round the cable and twisted together. The twisted ends of the wires shall be placed at right angles to and in the same plane as the natural bend of the cable.

The cable shall be straightened and clamped in the grip of the test apparatus, with the ink line underneath, so that the twisted wires are 7·6 mm from the grip edge. With the balance on its knife edges and the balance pointer at zero, the cable shall be adjusted to touch the wire loop and the protractor reading noted. The cable shall be rotated clear of the wire loop, a weight placed on the scale pan and the cable brought down on to the wire loop. The grip shall be rotated slowly and the protractor reading noted immediately the balance pointer reads zero. The sample shall then be immediately lifted from the wire loop.

9.21.1 This cycle of operations shall be repeated with increased weights on the scale pan, so that a graph of load against angle of rotation can be plotted using the average results for the three samples tested.

9.21.2 The rotation in degrees to counterbalance given weights, obtained from the smooth curve, shall not be less than the figures specified in Table 8.

NOTE — This test is applicable to cable sizes 20 and 22 only.

9.22 Climatic Test — For conditioning the cable samples it is permissible to use three separate chambers: (a) a dry heat chamber, (b) a low temperature chamber without low pressure facilities, and (c) a high humidity chamber. When separate chambers are used, the samples shall be transferred, as quickly as possible, from one chamber to the other.

When conditioning the cable samples to **9.22.1** and **9.22.3** a specimen of the cable shall be made into a coil, the ends of the cable being sealed and brought outside the test chamber. For cables with an overall diameter of 6·35 mm the mandrel diameter shall be six times that of the cable diameter and there shall be six turns of cable, but for the larger cables the mandrel diameter shall be 12 times that of the cable, and there shall be two turns of cable.

After conditioning in accordance with **9.22.1** and **9.22.3** the cable shall not show to normal vision any appreciable signs of deterioration. In addition, the specimen shall be immersed in water except for approximately 10 cm at each end and a voltage of 1 500 Vrms of waveform as specified in **9.13**, shall be applied between the conductor and the water for one minute. There shall be no breakdown.

After the application of the voltage test, the insulation resistance of the cable measured in the water at room temperature at 500 volts dc shall be equivalent to 4·57 MΩ for 1 000 metres at 20°C.

9.22.1 *Conditioning of Samples* — The sample shall be subjected to the following cycles of heat, cold and humidity:

1st day — Start of 24 hours period dry heat at 70°C

2nd day — Transfer to cold chamber at − 65 + 0 − 10°C for 8 hours
Transfer to humidity chamber at 40°C and 100 percent R.H. for 16 hours

3rd day — Transfer to cold chamber again for 8 hours
Transfer to humidity chamber for 16 hours

4th day — Transfer to cold chamber for 8 hours
Transfer to humidity chamber for 16 hours

5th day — Transfer to cold chamber for 8 hours
Transfer to humidity chamber for 16 hours

6th day — Transfer to extra-cold chamber at − 75°C for 6 hours

At the end of this period, the sample shall be removed from the extra-cold chamber and left at room temperature for one hour. It shall then be examined visually and subjected to the high voltage and insulation resistance tests as described above.

9.22.2 *Mould Growth Test* — This test shall be made on a separate sample and in accordance with IS : 9000 (Part 10)-1980*. A 25 cm length of cable shall have one end stripped back to expose 51 mm length of each of the component parts of the cable. The threads for the identification of the cable manufacturers and the year of manufacture of the cable shall also be visible. At the conclusions of this, no significant mould growth shall be apparent to normal vision and there shall be no appreciable deterioration of the component parts of the cable.

*Specification for environmental tests for electronic and electrical equipment: Part 10 Mould growth test (*first revision*).

9.22.3 *Tropical Exposure* — This test may be made either on a separate sample or on a sample that has been tested in accordance with **9.22.1**.

The sample shall then be conditioned for 28 days. After this period, the cable shall be examined visually and subjected to the high voltage and insulation resistance tests described above.

APPENDIX A

(*Clause* 3.1)

CLASSIFICATION AND IDENTIFICATION OF NYVIN CABLES

Cable Nomenclature	
Uninyvin	Uninyvinal
22	8
20	6
18	4
16	2
14	0
12	00
10	000
8	0000
6	—
4	—
2	—
1	—
0	—
00	—
000	—
0000	—

APPENDIX B

(*Clauses* 5.0.2.3 *and* 5.3.4)

B-1. FORMULAE FOR GLASS BRAID

B-1.1 Filling Factor — The filling factor K_f is defined as:

$$\frac{mnd_w}{2\pi D}\left(1+\frac{\pi^2 D^2}{L^2}\right)^{\frac{1}{2}}$$

B-1.2 Lay Factor — The lay factor K_L is defined as:

$$1 + \frac{\pi^2 D^2}{L^2}$$

where

D = mean diameter of braid (that is, diameter under braid + 2 d_r);
d_w = effective width of one end;
d_r = effective radial depth of one end;
L = lay length;
m = total number of spindles;
n = total number of ends per spindle.

Values of d_w and d_r for the sizes of yarn in common use for the cables covered by this specification are:

Glass Yarn Number	d_w	d_r
450/1/2	0·229	0·076
225/1/3	0·406	0·152

NOTE — d_w and d_r are affected by the number of turns per centimetre in the yarn used. The turns per centimetre in the yarn considered above must be as follows:

Single Yarn (*Turns per Centimetre*)	*Twist*	*Ply Yarn* (*Turns per Centimetre*)	*Twist*
1·8	*Z*	1·6	*S*

B-2. FORMULAE FOR METAL BRAID

B-2.1 Filling Factor — The filling factor K_f is defined as:

$$\frac{mnd_w}{2\pi D}\left(1 + \frac{\pi^2 D^2}{L^2}\right)^{\frac{1}{2}}$$

B-2.2 Lay Factor — The lay factor K_L is defined as:

$$1 + \frac{\pi^2 D^2}{L^2}$$

where

D = mean diameter of braid,
d_w = diameter of braiding wire,
L = lay of braiding wire,
m = total number of spindles,
n = total number of ends per spindle.

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APPENDIX C

(*Clause* 3.1)

MAXIMUM CURRENT RATINGS FOR NYVIN AND NYVINAL* CABLES

These current ratings are based on a temperature rise of 40°C and allow for an ambient temperature of 65°C; the maximum permissible conductor temperature is 105°C.

If the ambient temperature, t, is continuously in excess of 65°C; the current rating should be multiplied by the factor k where,

$$k = \sqrt{\frac{105 - t}{40}}$$

Uninyvin	Uninyvinal	Maximum Continuous Rating Amperes				Maximum 5 Minute Rating Amperes				Maximum 1 Minute Rating Amperes			
		Single Cable in Free Air	3-Bunched Cables in Free Air	7-Bunched Cables in Free Air	12-Bunched Cables in Free Air	Single Cable in Free Air	3-Bunched Cables in Free Air	7-Bunched Cables in Free Air	12-Bunched Cables in Free Air	Single Cable in Free Air	3-Bunched Cables in Free Air	7-Bunched Cables in Free Air	12-Bunched Cables in Free Air
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
22	—	11	7	5	4	12	8	7	6	15	12	9	9
20	—	14	9	7	5	16	12	9	8	22	19	15	15
18	—	18	13	10	6	23	17	13	12	30	26	19	18
16	—	21	15	11	7	25	19	14	13	33	28	26	25
14	—	31	24	17	12	36	28	24	21	50	47	43	42
12	—	43	30	22	15	50	38	32	30	72	67	62	60
10	8	61	47	36	25	71	56	48	45	110	107	104	101
8	6	87	65	49	36	105	89	82	80	173	165	159	153
6	4	115	87	65		152	122	115	—	250	236	230	—
4	2	160	120	92	—	225	185	175	—	390	378	360	—
2	0	200	155	120	—	305	265	250	—	545	530	520	—
1	00	220	165	130	—	330	300	290	—	620	600	590	—
0	000	240	185	168‡	—	370	350	340	—	705	690	680	—
00	0000	270	210/240†	190‡	—	420	410	405‡	—	820	810	800‡	—
000	—	300	235/265†	210‡	—	470	460	455‡	—	965	955	940‡	—
0000	—	350	270/305†	245‡	—	570	555	550‡	—	1 255	1 240	1 225‡	—

*The values of Uninyvinal cables have not been confirmed experimentally.
†Denotes two cables only.
‡Denotes five cables only.